

THE SARDINELLA FISHERY OFF THE COAST OF WEST AFRICA:
THE CASE OF A COMMON PROPERTY RESOURCE¹

by

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¹Paper presented at the Second Annual Conference of the International Association for the Study of Common Property (IASCP), September 26-29, 1991, University of Manitoba, Winnipeg, Canada.

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Abstract

Two species of sardinella, *S. aurita* and *S. maderensis* occur off the coast of West Africa in the Eastern Central Atlantic. Their distribution extends from Mauritania to the south of Angola with concentrations of distinct populations in three geographic sectors due to favorable environmental conditions. Because of their pattern of migration (both up and down along the coast and inshore-offshore pattern of movements), individual stocks are found in the territorial waters of two or more coastal countries at different stages of their life cycles. This makes it necessary for coastal countries to share information on the status of the stocks and for cooperation on the management of the fishery. The activities of national institutions, sub-regional and regional bodies, and international agencies in promoting the management of this common property resource are highlighted and discussed in terms of their effectiveness and relevance. Some suggestions are made for policy options and future research and management needs.

Résumé

On retrouve deux espèces de sardinelle, *S. aurita* et *S. maderensis*, au large de la côte ouest-africaine, dans le centre-est de l'Atlantique. On a pu observer leur présence de la Mauritanie jusqu'au sud de l'Angola, avec des concentrations de certaines populations dans trois secteurs géographiques en raison de conditions ambiantes favorables. A cause de leur comportement migratoire (aussi bien parallèlement à la côte qu'entre la côte et le large), on retrouve des sardinelles dans les eaux territoriales de deux ou plusieurs pays du littoral à différentes étapes de leur cycle de vie. C'est pourquoi il importe que les pays du littoral échangent de l'information sur l'évolution des stocks et collaborent à la gestion de la pêche. Les activités effectuées par les institutions nationales et les organismes infrarégionaux, régionaux et internationaux pour la gestion de cette ressource de propriété commune sont exposées ici et examinées quant à leur efficacité et à leur pertinence. Le tout est suivi de certaines suggestions en ce qui concerne l'élaboration de politiques, les orientations que devrait prendre la recherche et les besoins à satisfaire du côté de la gestion.

THE SARDINELLA FISHERY OFF THE COAST OF WEST AFRICA: THE CASE OF A COMMON PROPERTY RESOURCE

1. INTRODUCTION

The Eastern Central Atlantic³ (CECAF) region extends from the Straits of Gibraltar to the Congo River and covers nearly 10 000 kilometres of coastline (Figure 1). The climate along the coast is characterized by sub-tropical upwelling conditions in the north, desert and savannah conditions further south, and tropical conditions near the Equator. The coastal belt is mainly low-lying, and along the Gulf of Guinea is characterized by numerous lagoons behind narrow sand bars.

In general, the continental shelf in the CECAF region is less than 40 to 55 kilometres wide except in the area between latitudes 24°N to 20°N (Dakhla to Nouadhibou), and the area between Dakar (15°N) and Freetown (8°N) where the shelf is about 180 kilometres wide. The two major currents in the region are the cold Canary current flowing southward from northwest Africa, and the Benguela current flowing northward from southwest Africa. Both currents gradually flow westward at about 5°N and 10°S respectively, of the Equator. Between these two currents are the Equatorial countercurrent and its continuation, the Guinea current, which flows eastward into the Gulf of Guinea. These system of currents create seasonal upwellings which mainly account for the distribution of the fishery resources in the region.

Total marine production by West African countries showed an increasing trend during the 1980s although there were declines in some years (Figure 2). This increase in West African production is partly due to the expansion of the West African fleet (artisanal and industrial) in response to the decline of the foreign fleets in the region due to extended jurisdiction. In 1988 the West African fleet produced 1.6 million metric tons of seafood products from the marine environment. The catch of the foreign fleets operating in the region is not known with any certainty. The most abundant seafood resources are concentrated off a relatively low populated coastline stretching from southern Morocco to Sierra Leone. The per capita consumption of fish in the region is generally higher in urban than in rural areas, and expenditure on fish as a percentage of food expenditure is higher for low income groups. This indicates the importance of fish to the nutritional intake of poorer people in the region.

³For the purpose of this paper, the countries bordering the Eastern Central Atlantic extend from Morocco in the north, to Congo in the south, including the island countries. The region is referred to as West Africa since most of the countries are within this geographic area.

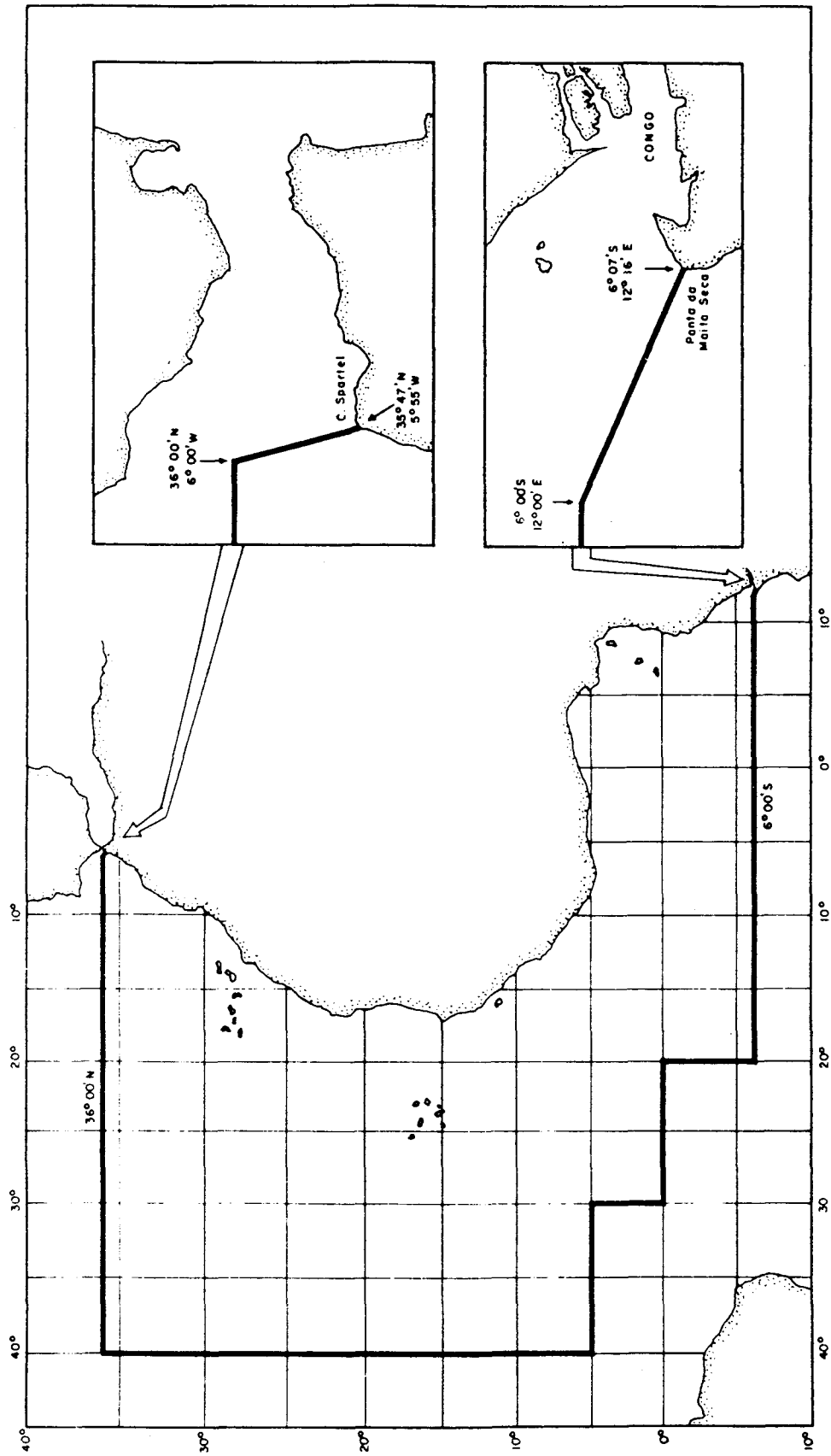
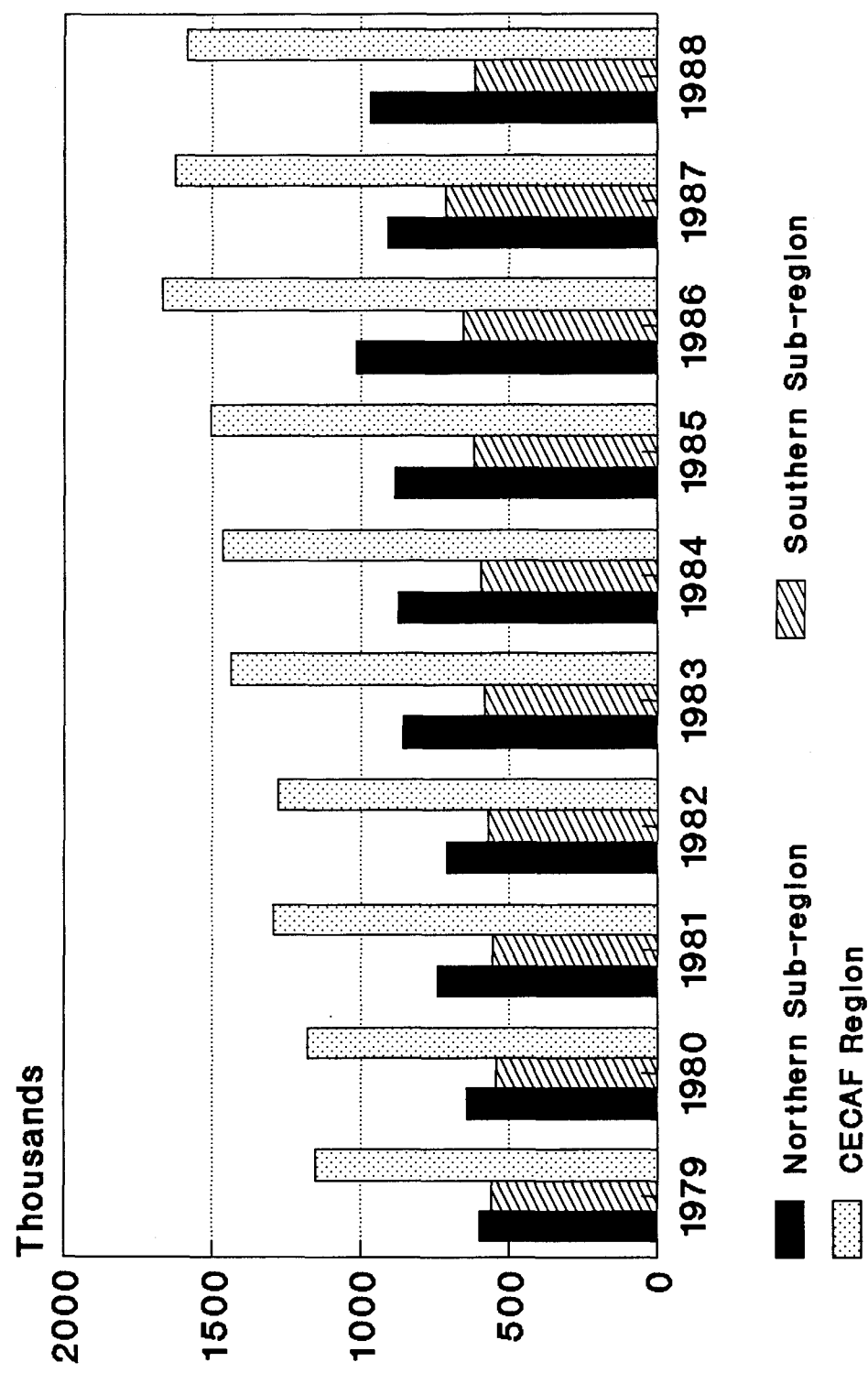


Figure 1: Map of the CECAF Region

Figure 2: Marine Production in the CECAF area by coastal countries



Notes: The northern sub-region includes coastal countries from Morocco to Sierra Leone and the southern sub-region includes countries from Liberia to Zaire

Source: FAO Yearbook of Fishery Statistics: Catches and Landings (Various Volumes)

Given the nature of the marine seafood resources in the region, there are potential benefits to be derived if efforts are made to manage and develop the resources efficiently. The sardinella fishery off the coast of West Africa offers one such possibility. This fishery is of particular importance because of its potential as a low cost source of protein for millions of people in the coastal countries. Large volumes of frozen and processed products are also traded intra-regionally. However, because of the highly migratory nature of the sardinella fish stocks and the different groups that participate in this fishery, coastal states are faced with a number of management problems.

Because the sardinella stocks move across national boundaries during their migrations no one coastal state can claim full jurisdiction over any particular stock. Thus, in the absence of any enforceable regulatory measures between states sharing these stocks, no one has any interest in preserving the sustainable nature of this common property resource. Added to this are biological and environmental factors that cause significant yearly fluctuations in the abundance of the stocks.

This paper reviews the distribution and current state of exploitation of the sardinella fishery off the coast of West Africa (CECAF region). It also discusses the common property characteristics of this fishery and the implications for effective management policies. Some insight is provided on the various efforts made to manage this fishery on a collective basis. The effectiveness and relevance of these efforts are discussed in terms of the importance of the fishery as a low value protein source, promotion of intra-regional trade, employment creation and the general improvement of the socioeconomic status of coastal people. The final section suggests ways by which future management strategies could be improved to ensure more rational utilization of the resource.

2. THE DISTRIBUTION AND STATE OF EXPLOITATION OF THE SARDINELLA FISHERY OFF THE COAST OF WEST AFRICA (CECAF AREA)

Two distinct species of sardinella are found in the CECAF region. The round sardinella (*Sardinella aurita*) and the flat sardinella (*Sardinella maderensis*). Due to the species mix in the CECAF region and the difficulty in catching small pelagic species such as sardinella with the gear used for trawl surveys, it has been impossible to estimate the total biomass for the two sardinella species to any degree of accuracy. CECAF Project reports estimate the potential of sardinella in the area between Mauritania and Guinea at around 400 000 and 600 000 tons, fluctuating yearly and sometimes close to one million tons. Marchal and Boely (1977) and Boely and Freon (1979) estimate the potential of sardinella in the Mauritania-Senegalese zone at 300 000 tons. Reports of echo surveys for the Cote d'Ivoire-Ghana sector estimates the potential at 250 000 tons (Marchal and Picaut, 1978), and at 359 000 tons

(Robertson, 1977). The potential of the sardinella stocks in the Congo-Angola sector has been estimated at around 600 000 tons (Anon., 1980).

2.1 *Sardinella aurita*

The round sardinella is found all along the West African coast, from the Mediterranean to Cape Frio (18°S). It lives on the continental shelf and prefers saline waters that are clear with a minimum temperature of less than 24°C . It is found abundantly in three sectors of the Eastern Central Atlantic that are characterized by the seasonal appearance of important cold water upwellings (Figure 3). These sectors are:

- from Mauritania (26°N) to Guinea (10°N), i.e., in the CECAP Sahara (Littoral) and Cape Verde (Littoral) divisions;
- off Cote d'Ivoire and Ghana, i.e., in the Gulf of Guinea (West) division;
- from South of Gabon (0°) to the South of Angola (17°S), i.e. in the Gulf of Guinea (South) division and off Angola.

There are no other concentrations of appreciable fishery reported in the intervening zones. Each of these three big areas of concentration is quite certainly occupied by distinct populations, as the system of currents is not favourable to any exchanges between them (FAO, 1973).

In each of these three sectors, mature females as well as larvae in the plankton are found practically throughout the entire year. However, there are several maximum points of reproduction. Spawning takes place at average depths of the continental shelf and the larvae then drift to the coast on the superficial layer. This general system is strongly influenced by the particular conditions at the different sectors where it takes place (Troadec and Garcia, 1980).

In the Sahara (littoral) and Cape Verde (littoral) divisions, the most important breeding period begins south of Dakar in May, carries on into June over all the Senegalese coast and then northward up to Cape Timiris (19°N) to conclude in July-August off the coast of Mauritania. Spawning seems to take place between 30 and 50 metres depth. The larvae carried north and toward the coast by the surface currents grow rapidly and reach three centimetres in a month (Conrad, 1977). They collect in vast nurseries located, in particular, between the Gambia and Cape Verde Peninsula, along the Mauritanian coast between 17° and 18°N , inside the Arguin Bank and in the Bay of Levrier.

A second reproductive cycle, in which only the young are

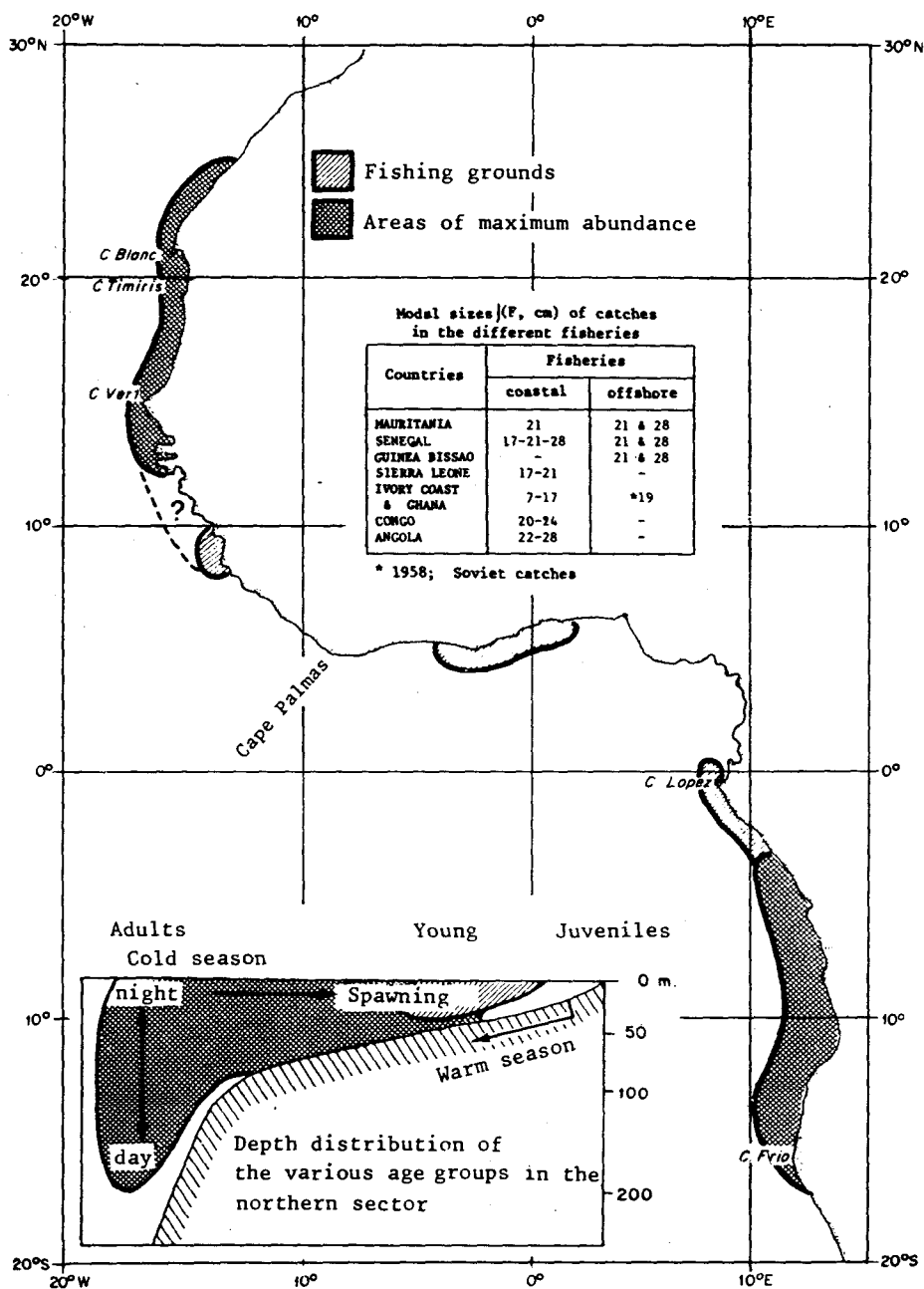


Figure 3: Round Sardinellas (*Sardinella aurita*). Main zones of abundance and fishery, main size classes in the various fisheries and depth distribution of the different stratas of population in the northern sector (adapted from FAO, 1971)

involved, has been noted in October-November off the Senegalese coast. This spawning is coastal and its volume varies greatly from one year to the next. From January to March there are more spawnings on the edge of the continental shelf, but their importance is slight and it is uncertain what becomes of the larvae that are then carried South and into the open sea (Conrad, 1977; Boely et al, 1978).

In this zone, *S. aurita* reaches a maximum size of 32 centimetres and growth is rapid. Adults of between 25 and 32 centimetres in size move seasonally along the coast between Mauritania and the Bissagos Islands. They get to Senegalese waters in December-January and they then concentrate along the edges of the shelf between the Cape Verde Peninsula and Guinea Bissau and remain there until April. Starting in May, with the warming-up of the surface waters, they colonize the continental shelf and by starting to breed they initiate their movement northward. At the end of their first year, the young join them in carrying out their first reproduction cycle. In July, these fish reach the Arguin Bank and remain there until October-November between 20°N and Cape Barbas. With the reestablishment of the upwelling, they start a new migration toward the south (Boely et al, 1978).

During the entire cold season deep sea trawlers fish the adult north of 20°N. These are mainly foreign vessels. No data is available on the number and characteristics of these vessels. The presence of the round sardinella in the catches of seiners have also been noted. However, the industrial Senegalese purse seine vessels ceased operations in 1987 because of declining profitability. There are foreign industrial seiners operating in this sector, but there is little information on their activities. The artisanal purse seiners (mainly of Senegalese origin) which number over 450, fish the adults all year round (Deme, 1986). The artisanal fishermen conduct their fishing operations according to the movement of the fish stocks. Thus, although there are major landing sites along the coast from which these fishermen operate, there are reports of migratory movements of fishermen north to Mauritania, and South to Guinea Bissau (Table 1).

South of this sector, off the northern coast of Sierra Leone, concentrations of round sardinella have been observed from January to May, and these are fished by seiners. They seem to leave this sector in May and head north (FAO, 1971). Not much information is available on these concentrations and any connexion between them and the Senegalese-Mauritanian group remains to be demonstrated.

In the Gulf of Guinea (West) division, the migration pattern of the Cote d'Ivoire - Ghana stock as well as its main biological functions and its fishery, are intimately bound up with the upwelling cycle (Figure 4). During the first half of the year, before the cold water begins to rise up, the adult population winters at depths ranging from 50 to 80 metres between the

Table] - Round sardinella (*Sardinella aurita*) in the northern sub-tropical zone: seasons and types of fishery by geographical sectors

Sectors	Sound-ings (m)	Strata exploited	Known fishing seasons	Known type of exploitation
Guinea-Bissau 11°-12°N	20-50 50-200	young, adults	March-April March-April	Large-scale (seiners)
South Senegal and Gambia 12°-15°N	0-10	juveniles	all year	Beach seine
	10-30	young	March-July Sept.-Jan.	Canoes and local seiners
	50-200	adults	Jan.-April	Local seiners
			Feb.-May	Large-scale (seiners and trawlers)
Northern Senegal 15°-17°N	50-200	adults	May-June	Large-scale (seiners)
	50-200	adults	March-June	Large-scale (trawlers)
South Mauritania 17°-19°N	20-50	young	November	Large-scale (seiners)
	50-200	adults	January June-July	Large-scale (seiners)
			Dec.-April June-July	Large-scale (trawlers)
North Mauritania 19°-24°N	10-30	young	all year	Local seiners
	50-200	adults	June-Dec.	Large-scale (seiners)
			all year	Large-scale (trawlers)

Source: Boely and Freon (1979)

longitudes of Cape Three Points and Accra. At the beginning of July, when the upwelling starts, the population moves closer to land and the surface, and thus becomes accessible to the local fleets particularly canoes from Ghana. Growth is then very quick. Spawning, which can be noted more or less throughout the year, is then at its maximum. Gradually, as the upwelling season progresses, the stock spreads out off the eastern half of Cote d'Ivoire and especially, toward the east as far as Togo.

At the end of this season, toward the month of October, the area of distribution of this stock begins to contract and in December the population returns to deep-waters for wintering. Similar displacements toward the coast and the surface are also produced with the small upwellings that are observed in January and sometimes later on, but their extent is equally restricted. Regardless of the season considered, these movements are small when compared to those of the populations in the other sectors. This difference is related to the absence in the Gulf of Guinea (West) division of any large thermal front comparable to the intertropical northern and southern fronts.

The maximum size of the round sardinella in the Cote d'Ivoire - Ghana population is around 25 centimetres, considerably less than the size reached by the Congo-Angolan population and those of Senegal and Mauritania (maximum size of more than 30 centimetres). Likewise, the size at first maturity (L_{50}) is here only 15 centimetres while it reaches 21 centimetres in Congo and 18.5 centimetres in Senegal (Fontana and Pianet, 1973).

There are three distinct fleets that exploit the round sardinella of the Cote d'Ivoire-Ghana population. In Cote d'Ivoire the industrial seiners numbered around 35 at its peak in 1969. Due to the collapse of the stocks in the early 1970s and other operational difficulties, the fleet size is presently less than 20 (Konan and Bard, 1986). There is no industrial fleet exploiting this fishery in Ghana. The semi-industrial fleet of purse seiners and purse seine/trawl vessels numbered around 400 in the late 1960s (Brainerd, 1984). Presently, about 140 are participating in this fishery. Well over 50 percent is probably out of commission because of economic reasons (personal observation). The artisanal fleet of canoes numbers around 700 and 8 000 respectively, in Cote d'Ivoire and Ghana. Most of them operate with purse seine and gill nets and also exploit the flat sardinella.

There are many similarities between the stocks in the Sahara and Cape Verde divisions and that in the Gulf of Guinea (south) division and off Angola. From South of Gabon to South of Angola, there seems to be only one stock. The adults move seasonally between these two limits following the oscillations of the southern inter-tropical front (Figure 5). Two major spawning periods have been observed off the coast of Congo, the main one from May to September and the other in January, i.e. during the two cold

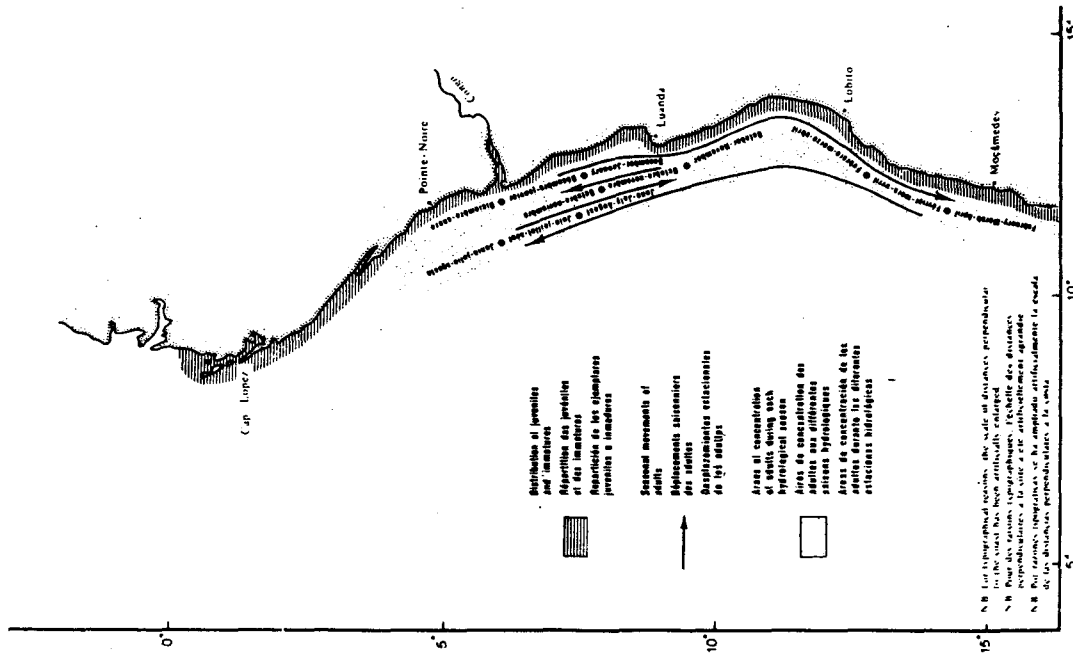


Figure 5 - Round Sardinella (*Sardinella aurita*) in the southern subtropical zone; Seasonal distribution and migration (From Ghéno and de Campos Rosado, 1972, In FAO, 1973a).

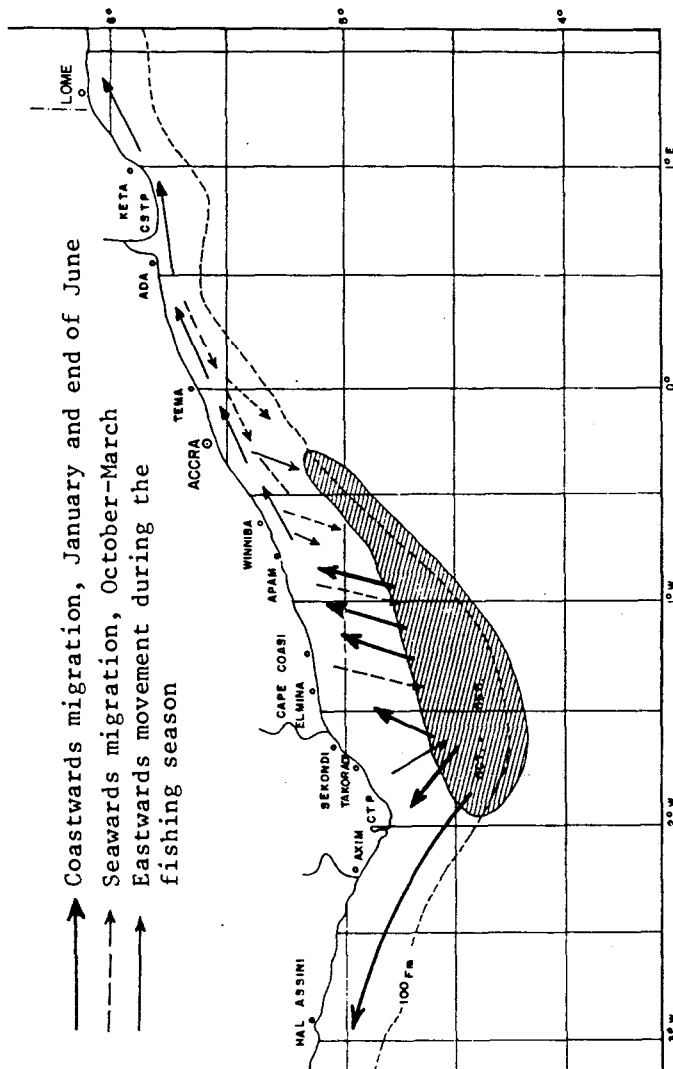


Figure 4 - Round Sardinella (*Sardinella aurita*) in the Gulf of Guinea (West) Division. Seasonal distribution and movements (From Ansa-Emmim, 1976, In FRU/ORSTOM, 1976).

seasons (Ghéno, 1975). The young colonize the entire coastal strip from the Bay of Tigers (Angola) up to Cape Lopez (Gabon), (Ghéno and de Campos Rosado, 1972). An important nursery area has been located between Mayumba (3°30' S) and Cape Lopez (0°30' S). It is likely that other nursery areas exist along the Angolan coast.

The young fish leave the coastal nurseries when they are between 10 and 14 centimetres and remain for sometime in the shallower part of the shelf before rejoining the adult population. It is at this time that the young become vulnerable to the coastal fisheries based at Point-Noire (Congo) and in the north of Angola (Luanda and Porto-Amboin). At Pointe-Noire, this recruitment takes place throughout the year with maximum point from September to January, and supplies most of the catch of round sardinella. North of Angola, the young contribute less than the adult to the catch where they tend to show up mostly in the main cold season (June to August). The adults from three years upward, migrate seasonally over very large distances (Figure 5) from the south of Angola up to Congo. This is the reason why they only appear in the Congolese catches in the middle of the cold seasons (July-August and occasionally in January). At Luanda and Porto-Amboin, where they supply the major part of fish catch, they are taken almost throughout the year except for the hot months (January-March) when they are only fished to the south, in the region of Porto Alexandre and the Bay of Tigers (Ghéno and de Campos Rosado, 1972).

Between 1° and 2°S, bait boats fishing for tuna catch small sardinella (10 to 18 centimetres) whose biological characteristics seem different from those of the above stock (e.g. 12 centimetres at first maturity instead of 20 centimetres). However, it is not known if this is a separate population (Fontana and Pianet, 1973). Also, north of Cape Lopez, Ghéno (1970) has reported the existence of an isolated, small-sized population which seems to possess distinct biological characteristics.

The Angolan purse seiners number around 20 at present. In recent times, Soviet purse seiners have been exploiting this stock. The number of seiners in the Soviet fleet is unknown. There is no significant industrial fleet exploiting the sardinella stock in Congo. The traditional canoe fishery in the Congo exploiting this fishery numbers around 600, although there seemed to have been some decline in recent years. No information is available on the artisanal canoes in Angolan waters, but catches of sardinella by this fishery are believed to be small (Anon. 1980). Catches in Angolan waters, except for some years during the war, account for over 90 percent of the total catch taken in this sector.

2.2 *Sardinella maderensis*

The flat sardinella is found from Mauritania to Angola. Although its ecological necessities are quite different, it has

more or less the same area of distribution as the round sardinella. It is more of a coastal fish, more euryhaline, most often found to be abundant near the outlet of water courses (Troadec and Garcia, 1980). It prefers warmer waters with a temperature above 24°C and seems to avoid waters that are not clear. Nevertheless, like the round sardinella, it is not very abundant in areas without upwelling where the warm and low saline superficial layer is permanently present (Figure 6). While spawning is continuous throughout the year, there is still a maximum reproduction point which is at the beginning of the hot season in Senegal, the hot season in Cote d'Ivoire and the cold season in the Congo. The young fish are concentrated in the coastal waters from where they gradually move off as they grow older; but stratification toward the open sea with age is never so clear cut as it is for *S. aurita* (Boely, 1979), and the great majority of the adults remain confined over the shallow half of the continental shelf.

The movements of this species are better known in the southern sub-tropical area (Congo-Angola). A similar population occupies the coast from Mayumba ($3^{\circ}30'\text{S}$) to Gabon as far South of Lobito (13°S) in Angola, with the juveniles spread along the coast throughout the area of distribution (Ghéno and de Campos Rosado, 1972). The individuals of between 14 and 20 centimetres then regroup between Mayumba and the north of Angola. The Congolese fishery mainly concentrates on this section of the stock. Starting from 20 centimetres, the young move toward the south and join the adults concentrated off Angola. Compared to the round sardinella, the adult flat sardinella are much more sedentary and they only travel limited distances along the coast. A distinct group which differs in biological characteristics from the Angolan population, seems to exist along the Gabonese coast (Ghéno, 1970).

In the northern sub-tropical zone, two important nurseries have been located, one from south of Dakar to the Bissagos Islands, the other at the level of the Arguin Bank and south of Cape Timiris. The young (16 to 24 centimetres) move seasonally for very limited distances inside these nurseries. Throughout the year they supply the main part of the catch for the coastal fleets and they also form part of the catch of the long distance fishery seiners when these operate sufficiently close inshore (Boely and Ostvedt, 1976). The adults (greater than 24 centimetres) are mostly found north of the Cape Verde Peninsula as far as Mauritania. They are captured by the Senegalese artisanal fishery using beach seines, surrounding gill nets and purse seine. They can also be found in the catches of deep sea seiners, but their contribution to the total catch is small. These adults seem to form a single stock, but their relations with the two nursery areas are still little known (Boely, 1979).

The flat sardinella is most abundant in two regions to the north and south of the Gulf of Guinea respectively (Figure 6). It is common from Cote d'Ivoire to Nigeria where it seems there are

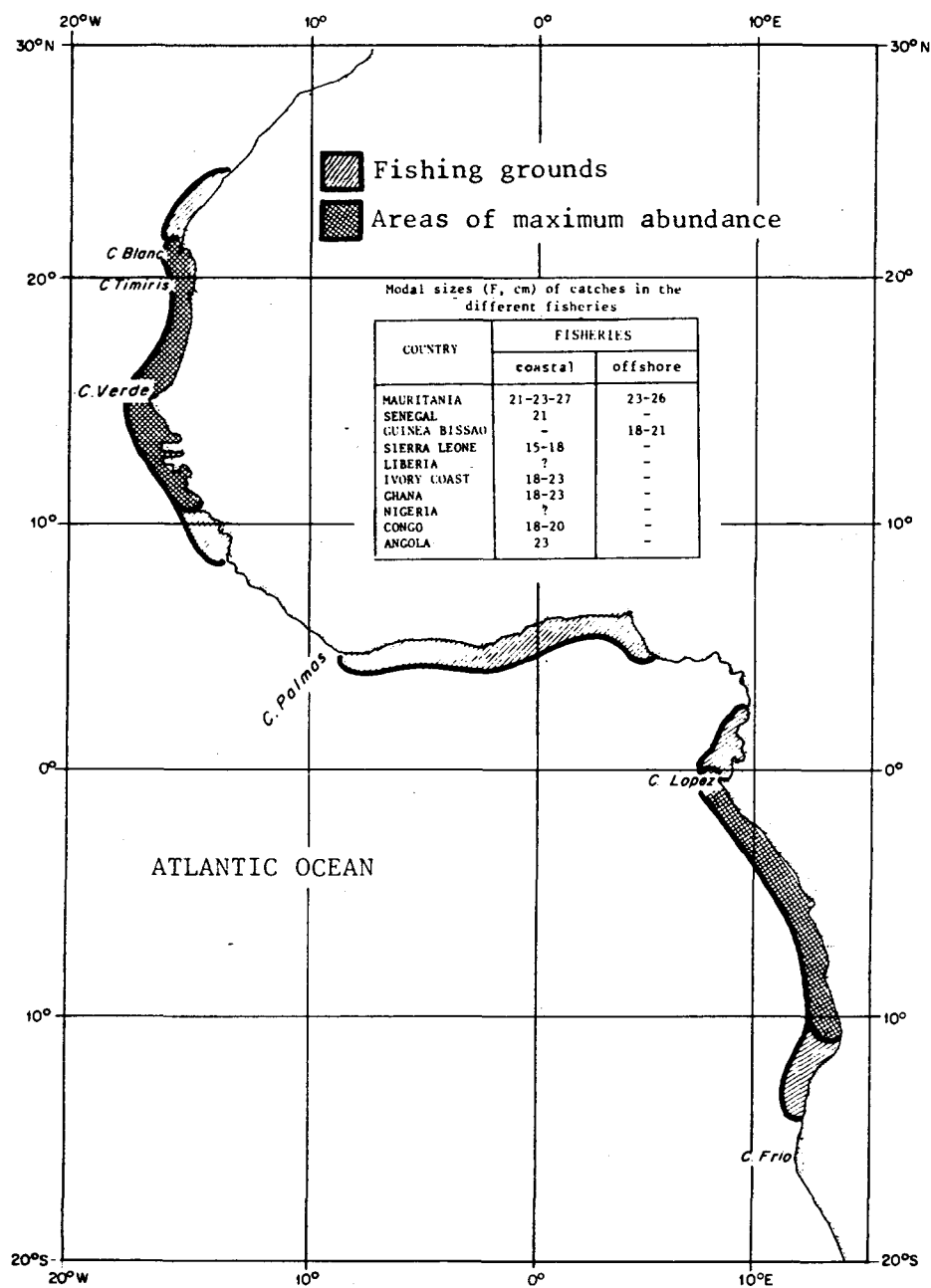


Figure 6 - Flat Sardinella (*Sardinella maderensis*). Main areas of abundance and fishing and main size classes in the various fisheries (modified from FAO, 1971).

several small populations that are of great importance for the local fisheries, particularly the artisanal type. In Cote d'Ivoire, the seiners catch mainly the adults and the young, while in Ghana the beach seine fishery catches mainly the juveniles.

Most catch statistics for the sardinella fishery in the CECAF region do not differentiate between the two species of sardinella. Usually, the statistics are grouped under *Sardinella spp.* Table 2 and Figure 7 provide annual catches for the CECAF region (all three sectors) for the period 1980 to 1988. The total figures indicate a decline from 1980 to 1984, except for 1983. Since 1985 the total annual catch seems to be on the increase. Table 2 also shows that from 1985 the percentage of *S. maderensis* identified in the catches is also increasing. It should be noted that some of the foreign fleets fishing the sardinella stocks under report their catches and in some cases do not provide statistics on their catches. Thus, the actual annual catch from this fishery could be a lot higher than the table indicates. This is one of the problems facing coastal countries in terms of the management of this fishery, since there is hardly any accurate assessment of the level of exploitation at the regional level.

3. COMMON PROPERTY CHARACTERISTICS OF THE SARDINELLA FISHERY AND THE IMPLICATIONS FOR EFFECTIVE MANAGEMENT

Given the pattern of distribution of the sardinella stocks in the CECAF region, they can be classified according to the nature of their movements, and to how their movements relate to the boundaries between national Extended Economic Zones (EEZs), and between EEZs and the high sea areas. Two basic types of movements (not mutually exclusive) can be distinguished during the life cycle of the sardinella stocks. The first type is the regular seasonal migrations and the second type is the regular movements in accordance with the growth and development of the fish.

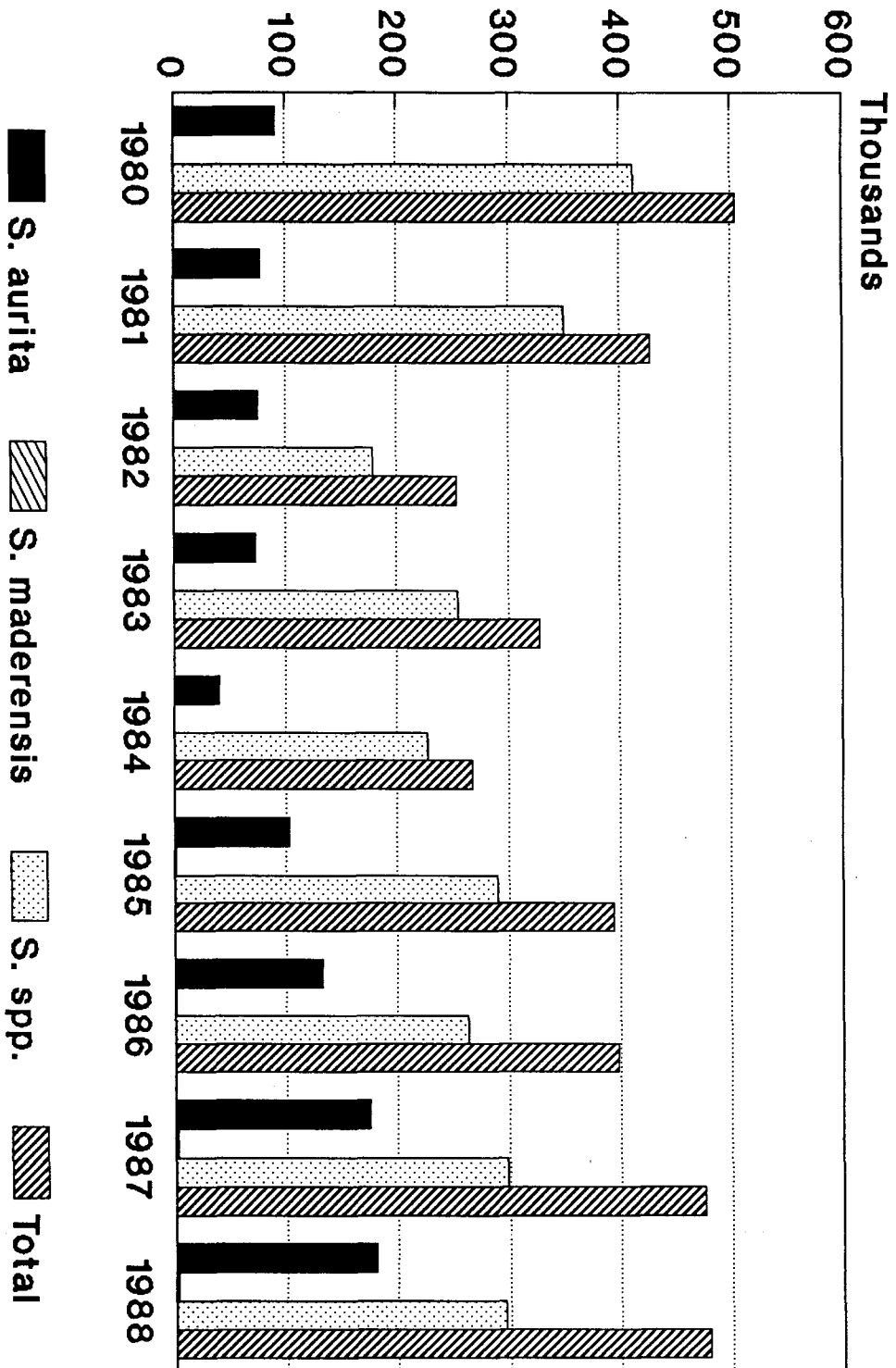
Since migrations require energy to perform, the sardinella stocks in the CECAF region take advantage of the upwelling conditions and current movements which produce changes in water temperature, marked seasonal changes in the food supply, and also allow the larvae and juveniles to drift in the right directions to ensure overall survival or recruitment success. Hence their abundance in areas where these conditions are prevalent. The relative abundance of the fish stocks also depends on the extent of the seasonal differences. Where the seasonal differences are quite marked, like in the sectors from Mauritania to Guinea and from south of Gabon to south of Angola, there are denser concentrations of stocks of larger sizes than in the sector off Cote d'Ivoire and Ghana where the seasonal differences are not so well marked. In addition to the up and down movements along the coast, there is also the inshore-offshore pattern of movements. The stocks migrate to inshore waters which are highly productive during

TABLE 2: Catches of Sardinella in the Eastern Central Atlantic CECAF Region (tons)

YEAR	S. AURITA	S. MADERENSIS	S.SPP.	TOTAL
1980	90 777		413 146	503 923
1981	77 537		349 605	427 142
1982	75 424		178 638	254 062
1983	73 505		254 383	327 888
1984	40 362		227 011	267 373
1985	103 167	951	289 318	393 436
1986	133 167	1313	263 501	397 896
1987	174 781	2483	297 851	475 115
1988	180 819	2483	296 169	479 471

Source: FAO Yearbook of Fishery Statistics: Catches and Landings (Various Volumes)

Figure 7: Catches of Sardinella in the Eastern Central Atlantic (metric tons)



Source: FAO Yearbook of Fishery Statistics: Catches and Landings (various volumes)

the warmer months for feeding and retreat to the deeper waters as the water temperature gets colder.

Movements in connection with the growth and development of the individual fish are critical to the long term survival of the fish stocks since the fish pass through a number of life stages that are extremely different in their nature and requirements. Thus, it is very necessary that the environmental conditions are favourable for these stages. During the first few months of life, the eggs and subsequently the larvae, generally drift somewhat passively with the prevailing currents. The larvae then settle in the nursery areas in the shallow coastal waters until they reach the size at which they join the main adult fish stocks. These processes are aided by the favourable environmental conditions.

As far as management policies and the needs for collaboration between countries are concerned, the patterns of movement have several implications. Although two types of migrations which are not mutually exclusive have been identified, there is need to examine the implications for each type of movement separately. The regular seasonal migrations result in a more balanced type of interaction. Fishing on the colder fishing grounds may affect the fishery on the warmer grounds in the subsequent year, but they in turn will be affected by fishing in the warmer grounds in previous years. The incentives for an agreement for coordinated management of the resources are therefore greater here than in the other pattern, in which the country whose fisheries act "upstream" of the others may be less immediately inclined to seek agreement.

For regular movements in accordance with the growth and development of the fish, apart from the return of the adult fish to the spawning grounds to complete the cycle, each fish move through each area (nursery grounds, feeding area, spawning area) once, and only once, during its life. The fisheries in different areas interact in a clearly hierarchical manner. Fishing in any one area will (so far as a given brood is concerned) only be affected by fishing "up stream" (i.e., on younger fish), and only affect those "downstream" on older fish. Interactions will be effective in the opposite direction (i.e., fisheries on older fish will affect those on younger fish) only to the extent that recruitment is affected by the abundance of adult fish. This is not always apparent, and (which is perhaps more significant in terms of getting agreement) is in virtually all cases difficult to demonstrate, at least until the recruitment has been seriously reduced. This could have been a factor in the collapse of the sardinella fishery in the Cote d'Ivoire - Ghana sector in 1972. It should be noted that prudent management of any stock should involve the maintenance of the minimum abundance of spawning fish, whether or not a relation with recruitment has been clearly demonstrated.

The effects of fishing on the stock at one place rather than another, and the benefits that can be gained from such fishery, are

not likely to be equal. The literature on the dynamics and management of fish stocks is full of studies showing the effects of varying the ages at which fish are caught. These show that there is loss in the yield by catching fish before the growth rates begin to slow and to be balanced by losses due to natural mortality. This is likely to cause problems when the nursery grounds lie in one EEZ and the adult stock in another. For example, in the Mauritania - Guinea sector, the spawning grounds are concentrated along the Senegalese coast, although it could extend to the south of Mauritania. In the Cote d'Ivoire - Ghana sector, the spawning grounds are concentrated in Ghanaian waters. And, in the Gabon - Angola sector, the spawning grounds are concentrated off the coast of Congo. Though older fish also occur in these zones the catches there tend to be fish smaller than the optimum size at first capture.

Given these common property characteristics of the sardinella fishery in the CEECAF region, particularly with the sharing of the same stocks by two or more coastal countries, it is desirable that these countries cooperate in the research, management and rational exploitation of the fishery. At the same time, there can be problems in achieving that cooperation. It can introduce another layer of administrative machinery into an overloaded system; meetings and travel between countries is expensive, and in particular some countries may be unwilling, with the adoption of EEZs, to take action which might appear as sharing authority over the fisheries in their EEZs. The next section looks at the efforts made in this area by national governments, sub-regional and regional groupings and international organizations.

4. COOPERATION IN THE MANAGEMENT OF THE SARDINELLA FISHERY

There are two types of cooperation involved between coastal countries with the management of the sardinella fishery in the CEECAF region. The first one is scientific cooperation, that is the study of the nature of the stocks, the levels of exploitation, environmental and other factors. In general, this is easy to achieve once there are funds to carry out the necessary activities. The second type of cooperation involves the formulation and implementation of appropriate management measures. This one raises problems of authority. Countries are free to take whatever action they think appropriate in the light of their national objectives and the available scientific evidence. However, even though countries are oftentimes parties to international agreements for such activities, they sometimes fail to implement such agreements for various reasons.

In terms of scientific research, the main benefit from international cooperation is that it becomes possible to consider all the information concerning the sardinella fish stocks, wherever they occur. In the absence of such information it is very easy for

a country to misinterpret what is happening to the stocks in its EEZ, even when it has good information on everything that is happening in that zone. For example, a small increase in national fishing effort could coincide with a large decline in catch rate due to a large increase in fishing on the same stocks elsewhere. This could be interpreted as too heavy fishing of the stocks, and lead to the introduction of severe control measures, if the events in the other areas were not taken into account. Cooperation between all countries in which the stocks occur, or in whose zones events occur that can affect those stocks would prevent this kind of action. Also, international agreements on management measures such as restriction on age at first capture, minimum mesh size, area restrictions, to name a few can prevent decimation of juveniles or spawning fish.

In recent years scientists in the region have come to realize that the nature of the information needed for management measures does not in simple terms involve calculating the total allowable catch (TAC) only, but that account has to be taken on the one hand of the existence of varied social and economic objectives, and on the other of the complexities of the natural ecosystem. Thus, for management measures to be effective information should be available to determine the social, economic and environmental consequences of different actions. For example, the cost of fishing (as influenced by catch rates, and the abundance of the stocks) and the seasonal and spatial distribution of the catches can be as significant as the magnitude of the total catch.

Cooperation in research for the management of the fishery resources in the CECAF region began before the coastal countries gained independence in the late 1950s and from 1960 onwards. Prior to independence the British and the French governments sponsored institutions involved in this activity. One regional oceanographic and fisheries research centre based in Freetown, Sierra Leone engaged in research work in the anglophone countries in West Africa. The French government established research centres in Dakar, Senegal; Abidjan, Cote d'Ivoire; and Point Noire, Congo. All these centres conducted oceanographic and trawling surveys involving the major commercial fish stocks, and scientists disseminated their results and discussed their findings. The activities of the regional centre sponsored by the British government ended when most of the countries gained their independence. The centres in the francophone countries are still active with some support from the French government.

Presently, there are three levels of institutions or bodies involved in fisheries and oceanographic research in the CECAF region. These are the national institutions consisting of research centres established by governments of some coastal countries. Next, are the sub-regional bodies involving groups of adjacent countries that have established committees with fisheries related activities. The third level consists of regional and international bodies that

are involved in fisheries management and development activities in the region. The following sections discuss the nature and activities of these three levels of institutions with reference to the management of the sardinella fishery.

4.1 National Fisheries and Oceanographic Research Institutions

In the Sahara and Cape Verde divisions only two countries have established fisheries and oceanographic institutions that are conducting research activities. The Centre National de Recherches Oceanographiques et des Peches (CNROP) in Mauritania conducts acoustic and trawling surveys through bilateral and multilateral assistance. In addition, fishery data are collected at the ports to include catches transiting through Nouadhibou. Trained inspectors also conduct on-board sampling. The main constraints are the shortage of high level scientists and local resources (mainly funding) for its activities. There is also problem with the collection of statistics from the artisanal fishery because of its dispersed nature. CNROP has participated at various scientific meetings evaluating the status of the sardinella stocks in the first sector.

The Centre de Recherches Oceanographiques de Dakar-Thiaroye (CRODT) in Senegal has been involved in intensive research programs. Industrial and artisanal fishery data collection and biological sampling are continuing processes in its activities. There are also adequate computer facilities for processing the data obtained from oceanographic and trawling surveys. The centre is perhaps the only one in the region with a fairly extensive social and economic program of fishery research. With regard to the sardinella fish stocks, its research activities have calculated abundance indices, conducted sampling for biological characteristics of the two species, trawling and acoustic surveys and monitoring of the environment (such as upwelling, zooplankton abundance, etc.) to better understand such factors as fish movement and changes in recruitment of the fish stocks; and socioeconomic surveys. The activities of this centre have been aided by bilateral and multilateral assistance. The Institut Francais de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM) provides some expertise and technical support for this centre on a continuing basis. CRODT has hosted a number of ad hoc working group meetings on the evaluation of the sardinella stocks in the Sahara and Cape Verde divisions.

The other countries in the Sahara and Cape Verde divisions do not have any research institutions involved in this type of activity. However, each country has government departments that collect and compile fishery statistics to varying levels. The information provided on the sardinella fishery through the activities of these departments are scanty and most of the data for the management of this fishery within the EEZs of these

countries are provided through the activities of sub-regional, regional, and international bodies.

In the Gulf of Guinea (West) division, Cote d'Ivoire, Ghana, Nigeria and Cameroon have oceanographic research institutes that are engaged in fishery research activities. However, only the activities of the first two are relevant to the management of the sardinella stocks in this division. The Centre de Recherches Oceanographiques in Cote d'Ivoire and the Fisheries Research and Utilization Branch of the Fisheries Department in Ghana have conducted significant research on the sardinella stocks in this division. Both institutions have also coordinated their efforts in terms of joint scientific activities. As a result, the information compiled on catch, fishing effort and abundance, biological data such as length composition, growth and mortality, recruitment, reproduction, and upwelling indices have been utilized to formulate management measures for the fishery. Attempts have been made to analyze the socioeconomic consequences of fluctuations in catches since the collapse and subsequent recovery of the sardinella stocks, but lack of data has prevented any meaningful analysis of this situation.

The Institut Francais de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM) in Pointe Noire, Congo has compiled data on catch, fishing effort, fleet characteristics, distribution and migration, growth, reproduction and mortality of the sardinella stock in the Gulf of Guinea (South) division. Although Angola has participated at scientific meetings with the Congo to evaluate the status of the sardinella stock, not much information is available on the state of this fishery in Angola's EEZ. This is cause for some concern because over 90 percent of the catch is taken in the EEZ of Angola.

In addition to the countries that fall within the three sectors, other countries in between these sectors with research capabilities (Sierra Leone, Nigeria and Cameroon) have research programs that conduct mainly biological studies on the marginal sardinella stocks that fall within their EEZs.

4.2 Sub-Regional Institutions with Fisheries Related Activities

Within the CEEAC region, there are two sub-regional bodies comprising coastal countries that are involved in fisheries management activities. These are the Conference of Fisheries Ministers of the Gambia, Guinea, Guinea Bissau, Mauritania and Senegal; and the Mano River Union (Guinea, Liberia and Sierra Leone). However, only the activities of the first one have some relevance to the management of the sardinella fish stocks in the Sahara and Cape Verde divisions. The main activity of this grouping is the annual meeting of the fisheries ministers to review their fisheries policies and management strategies on shared stocks.

There are also ad hoc working groups of fishery scientists from the five countries with special responsibilities to collect and analyze statistical and biological data on the shared stocks. These working groups have not functioned effectively due to lack of funds and other reasons.

However, through the sharing of information already available in the respective countries, the Conference of Fisheries Ministers have been able to compile a directory of fishing vessels operating in the EEZs of these countries, estimate catches for the sub-region based on the catch data available for each country, and agree on some management measures such as mesh size regulation, and effort limitation. These efforts have contributed toward improving the knowledge available for the management of the sardinella fishery.

Fishery management and development is actually just one of the activities of the Mano River Union. During the 1970s and early 1980s significant plans were made to enable cooperation in the management and development of shared stocks by these three countries. Such plans were never implemented and with the current political situation in Liberia and the economic problems facing Sierra Leone and Guinea, it is doubtful whether there will be any significant move in this direction in the near future.

4.3 Regional and International Institutions

The Economic Commission of West African States (ECOWAS) which comprises 17 countries has a fisheries division that has not been very active recently. Although this section has conducted studies in the past, no known policy initiative has resulted in this area. However, there has been some moves in other areas that could impact on the fishery in the region, particularly the sardinella fishery. One such move is the removal of tariffs on some products including fishery, and the creation of a free trade zone. Since sardinella forms the bulk of the fishery products traded intra-regionally, such a move will facilitate flow of sardinella from the north to the south and increase consumption of sardinella in the region.

A number of international institutions and donor agencies have also provided assistance for the management of sardinella and other fish stocks in the region. Among these, the Food and Agriculture Organization (FAO) has been the most prominent. FAO established the Fishery Committee for the Eastern Central Atlantic (CECAF) in 1967 with responsibilities related to marine fishery research, management and development. All the countries bordering the Eastern Central Atlantic and other countries with interest in the fisheries of this area are members of this committee. This committee itself is a statutory body. The sub-committees and working parties carry out the technical activities of this committee. There are two sub-committees on resources evaluation and management, and development

respectively. The sub-committee on resources evaluation and management has as one of its sub-groups, a working party on resources evaluation. This sub-group usually meets biennially to review the activities of the various ad hoc working groups. There are three ad hoc working groups (one for each sector) on sardinella stocks in the CECAF region.

The ad hoc working groups usually meet after the necessary scientific data have been collected by scientists in the various countries, to compile and analyze the data. Most of the work done by these three groups involve the collection of catch and effort data, and biological studies on the sardinella stocks. A few studies have provided some economic data on the sardinella fishery in some countries, but there is still a lot of work to be done in this area. The reports of the ad hoc working groups are reviewed by the working party on resources evaluation and when necessary further assignments are given to the ad hoc working groups. The working party makes recommendations to the sub-committee on resources evaluation and management based on the information received from the ad hoc working groups and finally the sub-committee suggests policy options for the management of the sardinella fishery to the committee. The committee which also meets biennially can adopt the policy measures which makes it obligatory for the member states to implement such policies. Policies already adopted by the committee for the management of the sardinella fishery include minimum mesh size regulation and effort control.

In addition to the activities of CECAF, FAO through the United Nations Development Programme and other donor agencies have conducted surveys and other biological work on the sardinella fishery in the region to provide information for management of this fishery. A number of bilateral donors have also conducted similar activities in the region for individual countries or group of countries. Although the information available to date is still inadequate for the effective management of this fishery, there has been considerable gains in understanding its dynamics and some countries have actually benefitted from such cooperative efforts. The next section discusses the effectiveness and relevance of these efforts particularly with regard to food supply in the region and improving the socioeconomic conditions of coastal fishing communities.

5. THE EFFECTIVENESS AND RELEVANCE OF COOPERATIVE EFFORTS FOR THE MANAGEMENT OF THE SARDINELLA FISHERY

It is important to recognize the dynamic nature of this resource. Because of changing environmental conditions leading to fluctuations in abundance of the sardinella stocks, information on the status of this fishery has to be updated constantly. Thus, the need for continuous research and data collection cannot be overemphasized. In order to evaluate the effectiveness of the

various efforts directed toward providing information for the management of the sardinella fishery, a number of questions should be posed. For example, how much has been achieved from all these efforts? How has the results of these efforts impacted on the management of the fishery? What actions have individual governments taken? What actions have been taken collectively on a sub-regional or regional basis? and finally, what are the constraints?

It is difficult to answer the first question precisely. The discussion in the preceding section shows that research activities in the CEEAF region vary greatly from several countries in which there is only a limited research program to countries with very extensive activities, manpower and equipment. Shortage of funds and perhaps, unawareness of the need for such programs are two of the major reasons why such research activities do not exist in some countries. These countries rely on research work undertaken through bilateral and multilateral arrangements, or from local universities. A few countries have extensive research programs including such activities as socioeconomic surveys, sampling for biological characteristics and catch assessment, trawling and acoustic surveys, and monitoring of the environment to better understand such factors as fish movement and changes in recruitment of the sardinella stocks.

What is obvious is that significant information has been documented and are available to all interested parties on catch and effort, the biological characteristics of the sardinella fishery, and on oceanographic factors. For some of the major sardinella producing countries, information is also available on fleet characteristics, production economics and marketing. The latter set of information do not form enough time series to enable the formulation of predictive models, but do provide some insight to the socioeconomic conditions prevailing in the fishery. However, there is enough evidence to assess the current state of exploitation to a reasonable degree. CEEAF countries were been advised on the state of the stocks on a regular basis. Most of the work done on the socioeconomic aspects of this fishery indicate that the small scale (artisanal) fishery in most of the countries is more efficient in exploiting the sardinella stocks. Thus, its efficient management and rational exploitation could bring significant benefits to the small scale fishermen whose livelihood and that of their communities depend on it.

In assessing the impact of management measures, two factors are of relevance. The first is the will to agree on the management policies needed based on the scientific information. The second is the ability to implement and monitor the effects of these policies. Even though some countries may not recognize the need or do not have the funds to invest in research programs, each one agrees that there has to be some control over the exploitation of this common property resource to maintain it in a healthy state and to preserve its renewable nature. In this regard, countries have acted

unilaterally or as a result of the recommendations of the CECAF committee to limit effort or impose other fishing restrictions. These actions to varying degrees have had some effects on the state of the fishery although there are other factors not related to management measures.

The major problem in the region is that most of the countries do not have the ability to implement and monitor the effects of these policies. The fishery sector in these countries take backstage to agriculture and with the declining economic conditions in most of these countries, funds for fishery management activities have been drastically reduced. As a result, the institutional structure needed to carry out such activities are slowly eroding and in some cases has already been eroded. Manpower availability is also a serious problem as most of the competent scientists leave these countries for more job satisfaction and greener pastures elsewhere. Some countries depend mainly on external assistance to conduct such activities even though they rely on the benefits obtained from the exploitation of the fishery.

Apart from the management policies mentioned above which most countries have at least on paper, governments have implemented some incentive programs to encourage the developemnt of the fishery and also at the same time monitor the level of effort directed toward this fishery. Such incentives include direct subsidies, exclusion of tariffs on imported inputs, tax free fuel, interest free or low interest loans, and free technical support services. Governments are able to monitor the number of firms or enterprises in the fishery through the registration of those who participate in the incentive programs. The main beneficiaries have been the small scale fishermen. On the consumer side, some governments have implemented price control mechanisms. Although one can find no economic justification for price fixing in situations where other sectors of the economy operate under free market conditions, by preventing fishermen from obtaining excess profits, governments are essentially preventing a rush of new entrants into the fishery.

The actions taken by sub-regional and regional bodies are mainly in providing training opportunities, organizing workshops and scientific meetings, and supporting management and development projects. These actions have assisted the countries in some ways in the management of the fishery. Based on the catches and landings of sardinella during the 1980s (Figure 7) there is no indication that there has been any significant increase in production. It is also uncertain whether the stocks can sustain further long term increases given the annual fluctuations in stock sizes. There is also the possibility of overexploitation of the fishery due to the introduction of improved fishing techniques. This could seriously affect the livelihood of the small scale fishermen. These factors further point to the need for more effective management regimes.

The formulation and implementation of appropriate trade

policies by these bodies can improve the flow of sardinella products from countries in the north to countries in the south of the region where there is excess demand for fish products. Such action should increase the supply of protein in the region. Also, countries can derive other benefits from effective trade policies. The promotion of intra-regional trade in sardinella products can also be achieved through improved processing and preservation methods, and improved road networks.

There are a number of constraints that limit the effectiveness of coastal countries in the management of the sardinella fishery. Chief among these is the prevailing economic conditions which make it difficult, and in some cases impossible for countries to commit funds to these activities. Along with this is the unavailability of hard currency for importing and maintaining technology essential for implementing some management measures. Next, the small sizes of some coastal countries make it infeasible to conduct certain activities individually. Lastly, the unstable political situations in some countries make it impossible to effectively implement policies in the long term. The next section suggests ways by which research and effective policy measures can increase the benefits from the exploitation of the sardinella fishery.

6. FUTURE RESEARCH ACTIVITIES AND POLICY OPTIONS

Given the need to constantly update the knowledge on the fishery, it is important that the activities of the research institutions in the region be strengthened and that avenues for cooperation among scientists and policy makers be improved. Future research efforts and policy options should have three main elements in focus. These are to provide information for regulating the fishery, to provide information for the allocation of the resource, and to formulate policies for the effective control of the fishery.

6.1 Regulation

Apart from the problem of interpretation of the available data, there is presently inadequate data on the sardinella fishery for effective management. Since regulations for conserving the fishery and improving its exploitation depend in the first instance on assessments based on adequate data, it is necessary to improve the system of data collection and analysis. However, there is a serious problem because the technical arm of the CECAF committee is presently non-functional due to lack of funds. Since 1988 there has not been any working group meeting and scientists from the different countries have not been able to meet under the auspices of CECAF to update their knowledge on the fishery. A way has to be found to continue the technical activities of CECAF. This would likely happen through support from international agencies and bilateral donors since coastal countries do not have the resources

for such activities at present. One possibility would be to establish permanent institutions that will carry out these activities.

An important element toward improving the management of this fishery is the likely shifting of emphasis from mainly biological objectives (e.g. maximum sustainable yield (MSY) to include economic and social criteria; and from being concerned with short-term management of the stocks (e.g., annual catch quotas) to longer term restructuring of the industry. Socioeconomic studies can allow for likely increased earnings in the future, and structural planning of fleets and support facilities can be carried out with greater confidence. This is of significant importance given the fluctuating nature of the sardinella stocks, the collapse of the Cote d'Ivoire - Ghana stocks in the early 1970s, the dependence of about 90 percent of small scale fishermen on this fishery for their livelihood, and the possibility that catch rates are unlikely to increase significantly at the current level of exploitation.

The monitoring of catch and effort data should be given more attention. Industrial vessels fishing the sardinella stocks should be required by law to provide more information on their catches, fishing grounds, vessel characteristics, etc. by means of logbooks. A system should also be devised to verify the information obtained from these vessels. Perhaps the greatest problem lies with the small scale fishery which is dispersed along the entire coastline of these countries. Considerable resources are needed to monitor the activities of these fishermen. Even if coastal countries can provide the resources to monitor their activities, their modes of operation make it difficult to use scientific sampling methods for statistical data collection. One way of overcoming this obstacle is to concentrate on a number of major landing sites and periodically conduct frame surveys on all the sites. With this approach, one can extrapolate to obtain the global catch within reasonable limits. With some education of the fishermen in terms of the benefits to them of proper management of the fishery, this process could achieve significant success.

6.2 Allocation

At present there is no system for allocating national quotas among the coastal countries and there is no way of telling whether it will be acceptable if one is designed. There are many political and historic factors that would lead one to believe that this is unlikely to happen. Also, the United Nations Conference on the Law of the Sea (UNCLOS) did not suggest any means for resolving allocation problems for shared stocks. However, since the exploitation of the sardinella stocks in the EEZs of some coastal countries affects the stocks in the entire geographic area or sector, effective management of these stocks cannot be carried out by individual countries regulating their exploitation

independently. There needs be common arrangements on TAC's and other conservation measures before any allocation can be effected. Each coastal country will want to ensure that the regulations are adhered to and this may in practice lead to the TAC being divided up into portions for each EEZ (i.e., zone quotas). This is an unfortunate development in many ways, but it is difficult to see how it can be avoided.

Once the coastal countries have divided up the property rights to the sardinella stocks among themselves each is free to allocate those rights among its own fishermen or to trade them off for reciprocal fishing rights, licence fees or other quid pro quo with third countries. It will be to the advantage of the coastal countries to gradually reduce the level of activity of the foreign fishing vessels exploiting these stocks and to improve the efficiency of the small scale fishery. In countries where the small scale fishery cannot be developed to exploit these stocks optimally in the near future for various reasons, consideration should be given to other coastal countries with the capacity to exploit these stocks and the need for more fish supply for domestic consumption. This could assist in improving the supply of protein in the region.

The multispecies nature of the fisheries in the CECAF region must be considered if zone quotas are to be given in any allocation process. Although sardinella stocks tend to appear singly in dense concentrations in some locations, it is not uncommon to find other species that feed on sardinella with these stocks at certain times. The abundance of the sardinella stocks also affects the abundance of their predators to some extent. This makes the process of allocation even more complex and the information requirements more demanding. What is needed is a system that will be sufficiently flexible to allow for exploitation without any catastrophic changes in the fishery for any particular species.

6.3 Control

Once regulatory measures for and allocation of the sardinella stocks have been achieved, a system of enforcing and monitoring should be implemented. Coastal countries will have to share the burden of enforcement. Sharing of information on the fishery will have to be improved and expanded. There might be the need for the establishment of permanent sub-regional or regional institutions to specifically coordinate and disseminate the information. Small scale fishing enterprises would probably be registered in each country and their activities monitored more closely. The system of centralized control may reduce the opportunistic element involved in gaining access to the resource and the cost of enforcement. Even if there is increased enforcement costs, this would be worthwhile if the benefits obtained as a result of these measures exceed the additional management costs.

The issue of control is a delicate matter in terms of coastal countries agreeing on any enforcement measures. The question of sovereignty could be a central sticking point as coastal countries are reluctant to agree to any enforcement measures that would make them appear as if they are relinquishing the sovereign rights over their EEZS. However, unless some credible control measures are instituted by all the countries concerned there is little hope of avoiding conflict of interest in the exploitation of the stocks and in preventing overexploitation in the long-run. The actual arrangements reached between the coastal countries would be the result of negotiations that would take account of many factors outside the fishery, particularly the general degree of collaboration between the countries.

7. SUMMARY

Two species of sardinella occur in the CECAF region. Their distribution is quite extensive, but there are three areas where high concentrations of sardinella stocks are present because of favourable environmental conditions. These areas are the Sahara and Cape Verde divisions, the Gulf of Guinea (West) division, and the Gulf of Guinea (South) division. Various reports have provided estimates on the stocks in these three sectors, but the figures are mere estimates since there are wide variations in the abundance of the sardinella stocks from year to year. The biology of both species, their migration, spawning and feeding habits are fairly well documented in various reports. Statistics on catch and effort are not very reliable, particularly for most of the coastal countries and information on the socioeconomic aspects of the fishery is scanty.

Because of the common property characteristics of this fishery, cooperation among the coastal states is essential to effectively control the exploitation of the stocks. The CECAF program has been the major body through which most of the activities concerned with the management of this fishery has been conducted since the early 1970s. Unfortunately, the technical activities of this committee has been suspended due to lack of funds. Action is needed to provide a system that would conduct these activities on a permanent basis. Research institutions in some adjacent countries sharing the sardinella stocks do have avenues for cooperation in research, but they still need external assistance.

The effectiveness of the various activities that have contributed toward providing information to manage the sardinella fishery could be assessed by posing a number of questions. These questions attempt to determine the impacts of research results, the actions taken by governments, sub-regional and regional commissions, and the constraints on the management of the fishery. Three factors are relevant to future management efforts. These

include providing information for formulating adequate regulatory measures and for allocating the resource to the coastal countries in a fair and equitable manner, and providing the facilities and manpower to enforce and monitor the activities in the fishery. To implement the last two factors will require a lot of goodwill on the part of the governments of the coastal countries.

REFERENCES

- Anon. 1980. Report of the ad hoc working group on sardinella stocks from Congo to southern Angola. CECAF/ECAF Series 80/20: 56p.
- Boely, T. 1979. Biologie des deux especes de sardinelles (*Sardinella aurita* Valenciennes 1847 et *Sardinella maderensis* Lowe 1841) des Cote sénégalaises. Thèse Doctorat d'état, Université de Paris VI.
- Boely, T. and Fréon, P. 1979. Les ressources en poissons pélagiques des Cotes ouest-africaines de la Mauritanie au Congo. FAO, Rome.
- Boely, t. and Ostvedt, O. 1976. Les poissons pélagiques cotiers au Senegal. Observations faites a bord du navire-usine ASTRA de le Mauritanie aux iles Bissagos. Bull. Inst. Fondam. Afr. Noire (A Sci. Nat.), 38(3): 677-702.
- Boely, t. et al 1978. Cycle sexuel et migrations de *Sardinella aurita* sur le plateau ouest-africain des iles Bissagos a la Mauritanie. Document présenté au CIEM/COI/FAO Symposium CINECA sur le courant des Canaries: upwelling et ressources vivantes, Las Palmas, Espagne, 11-14 avril 1978. Commun. (92): 12p.
- Brainerd, T.R. 1984. Lessons from fisheries development in West Africa: Purse seine/trawler construction, Ghana. ICMRD working paper No. 10 (FDSS working paper No. 5) 84/85-002: 34p.
- Conrad, F. 1977. Oeufs et larves de la sardinelle ronde (*Sardinella aurita*) au Sénégal: distribution, croissance, mortalité, variations d'abondance de 1971 a 1976 Cah. ORSTOM (Océanogr.), 15(3): 201-14.
- Deme, M. 1986. A bioeconomic simulation model for the Senegalese pelagic fishery (M.S. thesis), University of Rhode Island.
- FAO 1971. Working seminar on coastal pelagic resources of West Africa. Tema, Ghana, 1-5 November 1971. Rome, FAO, 64p. (mimeo).
- FAO 1973. Sierra Leone. Survey and development of pelagic fish resources. Report on project results: conclusions and recommendations. Terminal report. Rome, FAO, FI: DP/SIL/66/507: 30p.
- FAO 1973a. Department of Fisheries: Sedentary, migratory and intermingling species, their habitat and distribution. FAO FISH. Circ., (148) Rev. 1: 42p.

- Fishery Research Unit, Tema/ORSTOM. 1976. Rapport du Groupe de travail sur la sardinelle *S. aurita* des eaux ivoiro-ghanéennes. Abidjan, Cote d'Ivoire, 28 juin - 3 juillet 1976. Abidjan, ORSTOM, 63p.
- Fontana, A. and Pianet, R. 1973. Biologie des sardinelles *Sardinella eba* (Val) et *Sardinella aurita* (Val) des Cotes du Congo au Gabon. Doc. Sci. Cent. Pointe-Noire ORSTOM (Nouv. Sér.), (31): 38p.
- Gheno, Y. 1975. Nouvelle étude sur la détermination de l'âge et de la croissance de *Sardinella aurita* (Val) dans la région de Pointe-Noire. Cah. ORSTOM (Océanogr.), 13(3): 251-62.
- Gheno, Y. 1970. Note sur les sardinelles immatures de l'estuaire du Gabon. Doc. Sci. Cent. Pointe-Noire ORSTOM (Nouv. Sér.), (12): 20p.
- Gheno, Y. and de Campos Rosado, F. 1972. Distribution de fréquences de longueur des sardinelles, *Sardinella aurita* (Val) et *Sardinella eba* (Val), débarquées a Pointe-Noire et a St. Paul de Loanda (juin 1969-octobre 1970). Doc. Sci. Cent. Pointe-Noire ORSTOM (Nouv. Sér.), (26): 14p.
- Konan, J. and Bard, F.X. 1986. "La peche des petits pélagiques". Aménagement de la peche et de l'aquaculture en Cote d'Ivoire. CRO et Direction des Peches, ch. 4: 43-49.
- Marchal, E.G. and Boely, T. 1977. Evaluation acoustique des ressources en poissons du plateau continental ouest-africain des iles Bissagos (11°N) a la pointe Stafford (28°N). Cah. ORSTOM (Océanogr.), 15(2): 139-59.
- Marchal, E.G. and Picaut, J. 1978. Répartition et abondance évaluées par écho intégration des poissons du plateau ivoiro-ghanéen en relation avec les upwellings locaux. J. Rech. Océanogr., 2(4): 39-58.
- Robertson, I.J.B. 1977. Eastern Central Atlantic Fisheries, Summary report: FIOLENT 1976 Eastern Central Atlantic coastal fishery resources survey, southern sector. CECAF TECH. Rep., Dakar, (77/2): 115p.
- Troadec, J.-P. and Garcia, S. (eds.) 1980. The fish resources of the Eastern Central Atlantic. Part one: The resources of the Gulf of Guinea from Angola to Mauritania. FAO Fish. Tech. Pap., (186.1): 166p.